Fishery Data Series No. 99-28

Evaluation of the Arctic Grayling Stock in the Gulkana River, 1998

by

James T. Fish

and

Stafford M. Roach

October 1999

Alaska Department of Fish and Game Division of Sport Fish

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
metric ton	mt
milliliter	ml
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
ounce	oz
pound	lb
quart	qt
yard	yd

Spell out acre and ton.

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
hour (spell out for 24-hour clock)	h
minute	min
second	s

Spell out year, month, and week.

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.
All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.
and	&
at	@
Compass directions:	
east	E
north	N
south	S
west	W
Copyright	©
Corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
et alii (and other people)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.,
id est (that is)	i.e.,
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
number (before a number)	# (e.g., #10)
pounds (after a number)	# (e.g., 10#)
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)

Mathematics, statistics, fisheries

alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	F, t, χ^2, etc.
confidence interval	C.I.
correlation coefficient	R (multiple)
correlation coefficient	r (simple)
covariance	cov
degree (angular or temperature)	°
degrees of freedom	df
divided by	÷ or / (in equations)
equals	=
expected value	E
fork length	FL
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	log_2, etc.
mideye-to-fork	MEF
minute (angular)	'
multiplied by	x
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
standard length	SL
total length	TL
variance	Var

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James T. Fish and Stafford M. Roach
Division of Sport Fish, Fairbanks

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska, 99518-1599

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Development and publication of this manuscript were partially financed by the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under Project F-10-14, Job No. R-3-2 (f).

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James T. Fish and Stafford M. Roach
Alaska Department of Fish and Game, Division of Sport Fish, Region III,
1300 College Road, Fairbanks, AK 99701-1599, USA

This document should be cited as:
Fish, J. T., and S. M. Roach 1999. Evaluation of the Arctic grayling stock in the Gulkana River, 1998. Alaska Department of Fish and Game, Fishery Data Series No. 99-28, Anchorage.

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ABSTRACT

Catch composition studies of the Arctic grayling *Thymallus arcticus* stock in the Gulkana River were conducted during July 1998 and compared to historical data. Length and age distributions of fish captured in 1998 differed significantly from fish caught in 1990, 1991, and 1992 ($P < 0.01$). There were significantly more large fish (≥ 320 mm FL; ≥ 14 in) in the 1998 sample when compared to 1990, 1991, and 1992. There were also significantly more fish ≥ 270 mm FL (≥ 12 in) in the 1998 sample when compared to 1990, 1991, and 1992. Proportions in three critical length categories (150 to 269 mm FL, 270 to 319 mm FL, and ≥ 320 mm FL) were all greater than minimum threshold levels. Proportions were 0.50 for fish from 150 to 269 mm FL (~7 to 12 in TL), 0.31 for fish from 270 to 319 mm FL (~12 to 14 in TL), and 0.19 for fish ≥ 320 mm FL. This data along with relatively light exploitation (< 2,000 fish per year on average) suggests that abundance information is not needed at this time.

Key Words: Gulkana River, Arctic grayling, *Thymallus arcticus,* hook-and-line angling, age composition, length composition, stock assessment.

INTRODUCTION

The Gulkana River, situated in the Upper Copper River drainage, originates in the Alaska Range, and flows into the Copper River. Portions of the approximately 154 km long (96 mi) Gulkana River are classified as “Wild” by Congress, and are administered by the Bureau of Land Management (United Stated Department of Interior). The Gulkana River provides bank, float, and powerboat fishing opportunities to anglers, with access locations along the Richardson Highway. This river attracts visitors from both Fairbanks and Anchorage, and is a popular sport-fishing destination with nonresident anglers (Szarzi 1996).

The Gulkana River supports the second largest Arctic grayling *Thymallus arcticus* fishery in the State of Alaska (Howe et al. 1997; Howe et al. 1998) and the largest in the Upper Copper/Upper Susitna Management Area (Szarzi 1996). Both the greatest catch and harvest of Arctic grayling from the river typically occurs in the mainstem portion of the Gulkana River, which flows approximately 72 km (45 mi) from the outlet of Paxson Lake to the Sourdough campground (Figure 1). From 1993 to 1997, the estimated harvest of Arctic grayling from the mainstem averaged 1,641 fish and the estimated catch averaged 21,609 fish (Mills 1994; Howe et al. 1995; Howe et al. 1996; Howe et al. 1997; Howe et al. 1998). Participation in this fishery, measured by days fished for all sport fish species, increased substantially from 1993 to 1997, but harvest of Arctic grayling remained relatively unchanged during this period (Figure 2).

Past studies have examined life history patterns, including migrational habits and seasonal distributions of Arctic grayling in the Gulkana River (Roth and Delaney 1987; Roth and Alexandersdottir 1990; Vincent-Lang and Alexandersdottir 1990). Generally, adult summer residents of the mainstem portion spawn in tributary creeks, such as Poplar Grove and Sourdough Creeks, and presumably winter in deeper portions of the Gulkana River. Fish distribute themselves in the Gulkana River after spawning, according to size. Larger and older fish occupy the upper reaches of the river and smaller and younger fish the lower reaches closer to Sourdough. Young-of-the-year (YOY) Arctic grayling usually rear in their natal tributaries, however, during summers of low precipitation these tributaries occasionally dry up (Bosch 1995). It is assumed that Arctic grayling YOY rear in the mainstem Gulkana River during these circumstances.

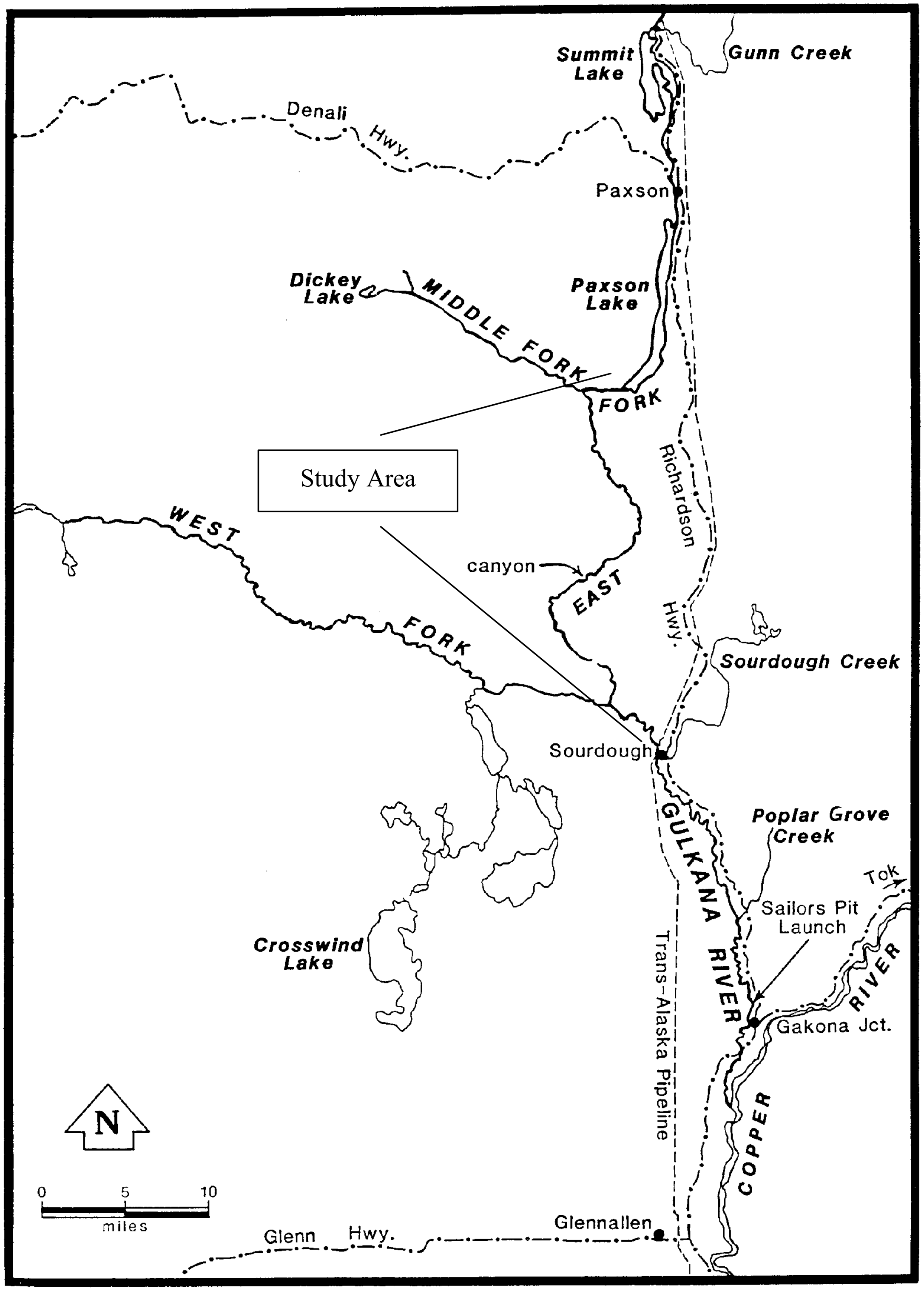
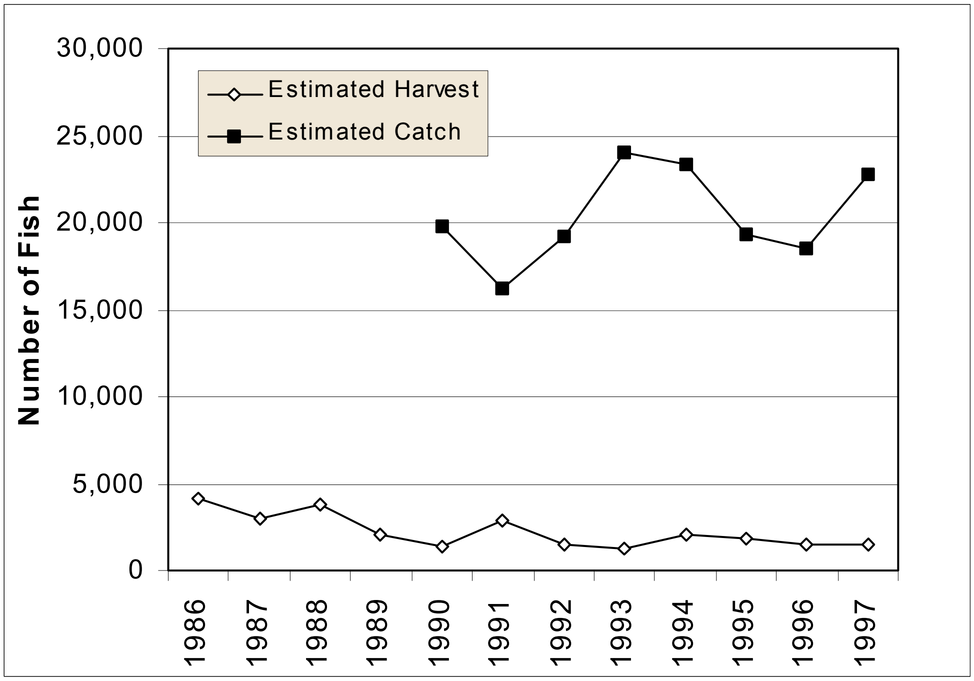


Figure 1.-The Gulkana River drainage and study area.

a



b

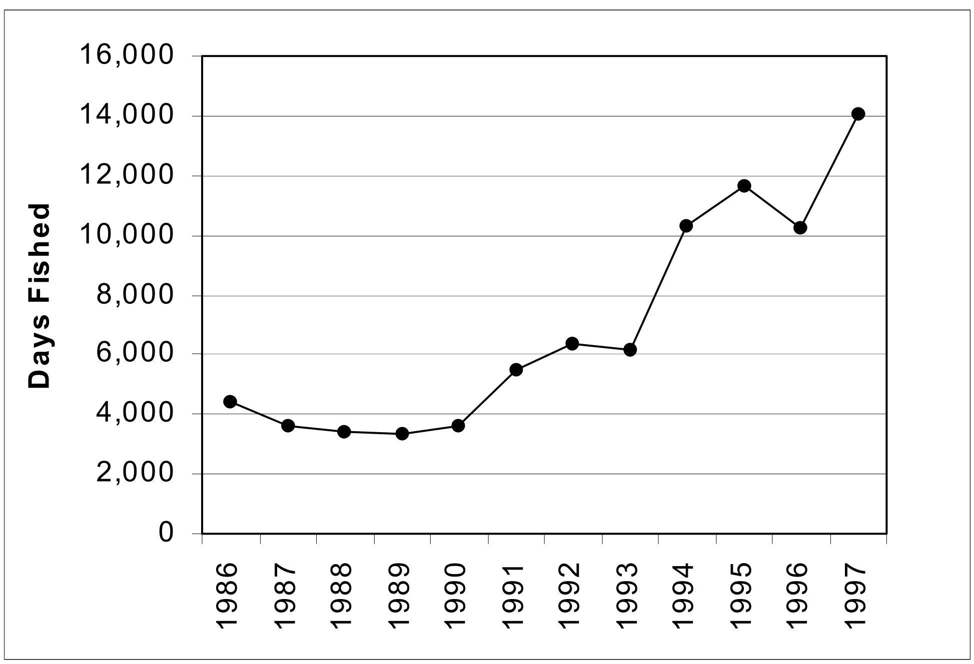


Figure 2.-Estimated catch and harvest (a) of Arctic grayling, and estimated participation (days fished) for all sport fish caught (b) in the mainstem Gulkana River.

Bosch (1995) reported historical information on Arctic grayling in the Gulkana River from studies between 1986 and 1991. The estimated abundance between 1987-1991 in the mainstem averaged 90,164 fish as determined from Jolly-Seber mark-recapture estimates. This compared to 114,148 (exploitable abundance 78,898) as determined from catch-age modeling during the same period. Abundance was not estimated after 1991. Otoliths from the sportfish harvest, however, were periodically collected between 1993-1997. However, collection methods for age structures were unrepresentative of the overall age composition of harvested Arctic grayling, and were not used in catch-age models to estimate population abundance. Bosch (1995) used catch-age analyses to determine sustainable exploitation rates for different stocks of Arctic grayling distributed within the Gulkana River drainage. He suggested sustainable exploitation rates that result in harvests as high as 12,000 fish for Arctic grayling in the mainstem Gulkana River.

Fishery research that began in 1986 resulted in the development of an Arctic grayling management plan that calls for the maintenance of historic abundance and composition, and provide quality angling opportunities (Roth and Alexandersdottir 1990; Vincent-Lang and Alexandersdottir 1990). To help achieve the goals of the management plan, a restricted regulation was adopted in 1988 to protect larger and older fish, and has been in effect since 1989 (Szarzi 1996). This regulation restricted the daily bag limit to five fish, which may include only one fish over 14 in TL (320 mm FL).

Since stock composition data for the years 1993-1997 is lacking, there was a need to collect age and size composition data from Arctic grayling in the mainstem Gulkana River to help managers monitor trends in stock compositions. The research objectives for 1998 were to:

1. estimate the age and length composition of Arctic grayling (≥ 150 mm FL) captured in the mainstem of the Gulkana River during the midsummer fishery, such that all proportions are within five percentage points of the true proportions 90% of the time;
2. test the hypothesis that the relative length composition of Arctic grayling (≥ 150 mm FL) captured in the mainstem of the Gulkana River was the same as that collected during 1992 such that a difference in the proportions of fish > 320 mm FL (14 in TL) of 10 percentage points can be detected with α=0.1 and β=0.2; and,
3. test the hypothesis that the age composition of Arctic grayling (≥ 150 mm FL) captured in the mainstem of the Gulkana River was the same as that collected during 1992 such that a difference of 10 percentage points in the proportions of Arctic grayling that were age-4 were the same such that a difference of 10 percentage points can be detected with α=0.10 and β=0.2.

In addition to the objectives and to form a basis for managers in evaluating length data in the absence of abundance information, three critical length categories were examined and compared to the historical data. Critical length categories were 150 to 269 mm FL (~7 to 12 in TL), 270 to 319 mm FL (~12 to 14 in TL), and greater than 319 mm FL. Minimum acceptable thresholds were identified as the lowest observed proportion within each length category (Table 1). An indication of concern should occur when any one category falls below the threshold. Management action should not necessarily be taken but a mark-recapture experiment would be warranted to compare current abundance to historical abundance. A management action should then be imposed if the 95% CI of the estimate of abundance does not include the historical average (exploitable average 78,898). Given the large size of the stock and the low rate of harvest, length information gathered every three to five years should be sufficient in determining the health of the stock unless either effort or harvest increases substantially. In which case, information should then be gathered more often.

Table 1.—Historical proportions of captured Arctic grayling within three length categories by year and minimum acceptable threshold.

Length (mm FL)	1990	1991	1992	Threshold
150 – 269	0.74	0.69	0.45	0.45
270 – 319	0.15	0.21	0.44	0.15
320 +	0.10	0.10	0.11	0.10

METHODS

The age and size composition of Arctic grayling (≥ 150 mm FL) sampled was estimated from fish caught within a 72 km portion of the Gulkana River, between the outlet of Paxson Lake and the Sourdough boat launch (Figure 1). Fish were collected with hook-and-line and sampled from July 24-29. Two crews of two or three people sampled from upstream to downstream as uniformly as possible. This procedure (including river portions, month, and gear type) mimics that used by Bosch (1995) in collecting historical data. The fork lengths of all fish were measured to the nearest 1-mm. For fish ≥ 150 mm FL, scales were taken and an internal anchor (T-bar) tag inserted at the left base of the dorsal fin.

Three to four scales were taken from each fish sampled for age. All scales came from an area on the fish approximately six scale rows above the lateral line and just posterior to the insertion of the dorsal fin (Brown 1943; W. Ridder *Unpublished*). Scales were placed on gum cards in the field and retained for age determination. Impressions of the scales were made on triacetate film using a scale press (30 s; 137,895 kPa; 97°C). Ages were determined by counting annuli from impressions of scales magnified to 40X with the aid of a microfiche reader. Criteria for determining the presence of an annulus were: 1) complete circuli cutting over incomplete circuli; 2) clear areas or irregularities in circuli along the anterior and posterior fields; and, 3) regions of closely spaced circuli followed by a region of widely spaced circuli (Kruse 1959). Determination of age was performed at least twice for each readable set of scales, and one reader read all scales.

Age proportions for the catch of fish ≥ 150 mm FL were determined as:

$$\hat{p}_k = \frac{y_k}{n} \tag{1}$$

where:

$\hat{p}_k$ = the proportion of Arctic grayling that were age k;

y_k = the number of Arctic grayling sampled that were age k; and

n = the total number of Arctic grayling sampled.

The variance of this proportion was estimated as:

$$\hat{V}[\hat{p}_k] = \frac{\hat{p}_k(1-\hat{p}_k)}{n-1}. \tag{2}$$

The standard error of $\hat{p}_k$ was calculated as:

$$SE[\hat{p}_k] = \sqrt{\hat{V}[\hat{p}_k]}, \tag{3}$$

and the coefficient of variation (CV) of $\hat{p}_k$ was calculated as:

$$CV[\hat{p}_k] = \frac{SE[\hat{p}_k]}{\hat{p}_k}. \tag{4}$$

The hypothesis that age composition of fish captured during 1998 was the same as that reported by Bosch (1995) during 1990, 1991, and 1992, was tested by chi-square contingency analysis. Because measurement error associated with the age determination process increases with older fish, ages 7 and above were pooled into a 7+ age group (W. Ridder, Alaska Department of Fish and Game, Delta Junction, personal communication).

Size composition was estimated similar to age composition, replacing age classes with size classes. Additionally, the mean length-at-age (L_k) of fish collected during 1998 was calculated as the arithmetic mean length of all fish assigned to the same age:

$$\overline{L}_k = \frac{\sum_{j=1}^{n_{kl}} L_{jk}}{n_{kl}} \tag{5}$$

where:

L_{jk} = FL (mm) of the j^{th} fish sampled that was age k; and,

n_{kl} = the number sampled for length l that are age k.

Standard error (standard deviation of the mean) was calculated as:

$$SE = \sqrt{\frac{\sum_{j=1}^{n_{kl}} (L_{jk} - \overline{L}_k)^2}{n_{kl}(n_{kl}-1)}}. \tag{6}$$

To test the hypothesis that length compositions from fish captured during 1998 is the same as that reported by Bosch (1995) for 1990, 1991, and 1992, a two-sample Kolmogorov-Smirnov test was performed using cumulative length distribution data from each year (Conover 1980). Additionally, the number of fish ≥ 270 mm FL (~12 in TL) captured during 1998 was compared to those captured during 1990, 1991, and 1992, using chi-square contingency analysis. Likewise, the number of fish ≥ 320 mm FL (~14 in TL) captured during 1998 was also analyzed.

All data pertaining to length, sampling induced mortality, tag identification numbers and colors, and recapture status were recorded on Alaska Department of Fish and Game Tagging Length Form, Version 1.0. In addition, capture and release locations (landmark features and GPS readings), and CPUE data were recorded on spreadsheets and electronically stored for archival (Appendix A). Mean length-at-age and sample sizes by length and age class were archived (Appendix B).

RESULTS

A total of 408 fish were captured during 1998, of which the lengths of 401 and the ages of 364 were used for data analyses. Sample size required for desired precision was met with length data, but not with age data. Composition data was compared to that collected by Bosch (1995) during July 1990 and 1991, and late July and early August 1992.

For critical length categories, proportions were 0.50 for fish from 150 to 269 mm FL (~7 to 12 in TL, 0.31 for fish from 270 to 319 mm FL (~12 to 14 in TL, and 0.19 for fish greater than 319 mm FL. The greatest proportion of fish sampled during 1998 were in the size class of 265 to 275 mm FL, or approximately 12 in and slightly greater (Figure 3). Cumulative length distributions of fish captured in 1998 differed significantly from fish caught in 1990 ($DN = 0.32$, $P < 0.01$: Figure 4), 1991 ($DN = 0.21$, $P < 0.01$; Figure 5), and 1992 ($DN = 0.11$, $P < 0.01$; Figure 6). There were significantly more large fish (≥ 320 mm FL; ≥ 14 in) in the 1998 sample when compared to 1990, 1991, and 1992 (Table 2). There were also significantly more fish ≥ 270 mm FL (≥ 12 in) in the 1998 sample when compared to 1990, 1991, and 1992 (Table 3).

The largest proportion of fish captured during 1998 was age-3. There were significant differences in age composition when compared to 1990, 1991, and 1992 (Table 4). Again, with a greater proportion of larger and older fish in 1998 than in 1990, 1991, and 1992 (Figure 7).

DISCUSSION

Stock composition data of mainstem Gulkana River Arctic grayling were collected in 1998 and compared to data from 1990-1992. Fish were sampled entirely with hook-and-line gear during July of 1998. Vincent-Lang and Alexandersdottir (1990) found that, by comparing length distributions of recaptured Arctic grayling with those originally marked within portions of the Gulkana River, there was size-selectivity with electrofishing gear within certain sections of river, but did not rule out size-selectivity with the use of hook-and-line gear. Nonetheless, hook-and-line gear was the chosen gear type used during 1998 because it would enable a better comparison with the historical data reported by Bosch (1995) in the early 1990s.

The composition of Gulkana River Arctic grayling was significantly different in 1998 than the composition in the early 1990s in that there were more older and larger fish. This shift in composition is probably related to the more restrictive regulation instituted in the early 1990s to help alleviate the problem of anglers targeting larger-sized fish in the 1980s (Williams and Potterville 1983). Now, with the presence of a greater proportion of large fish along with an acceptable proportion of young fish, this stock appears as healthy or healthier than in the 1980s and early 1990s.

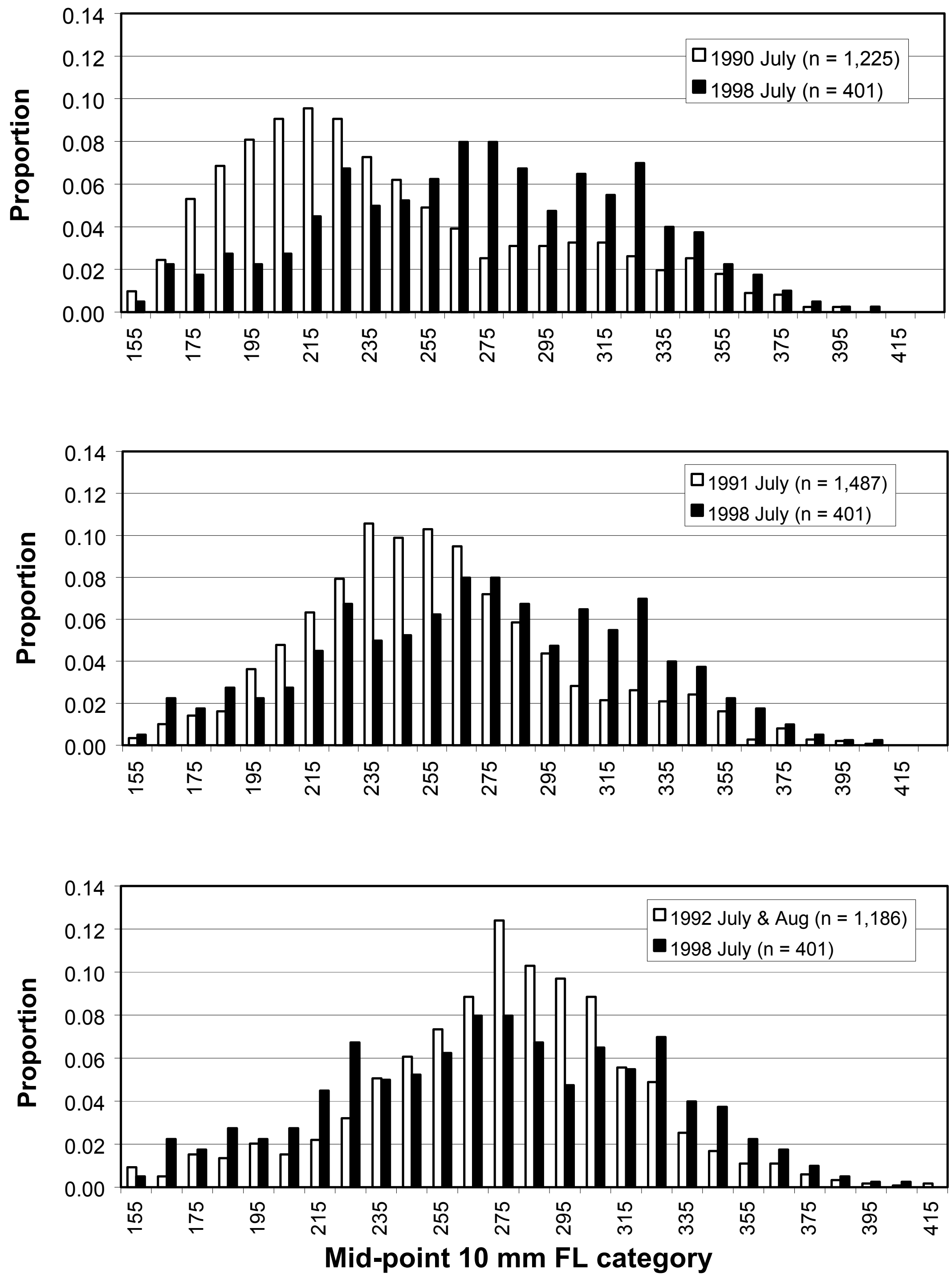


Figure 3.-Size composition of Arctic grayling ≥150 mm FL sampled in the Gulkana River during 1998 and 1990(a), 1991(b) and 1992(c).

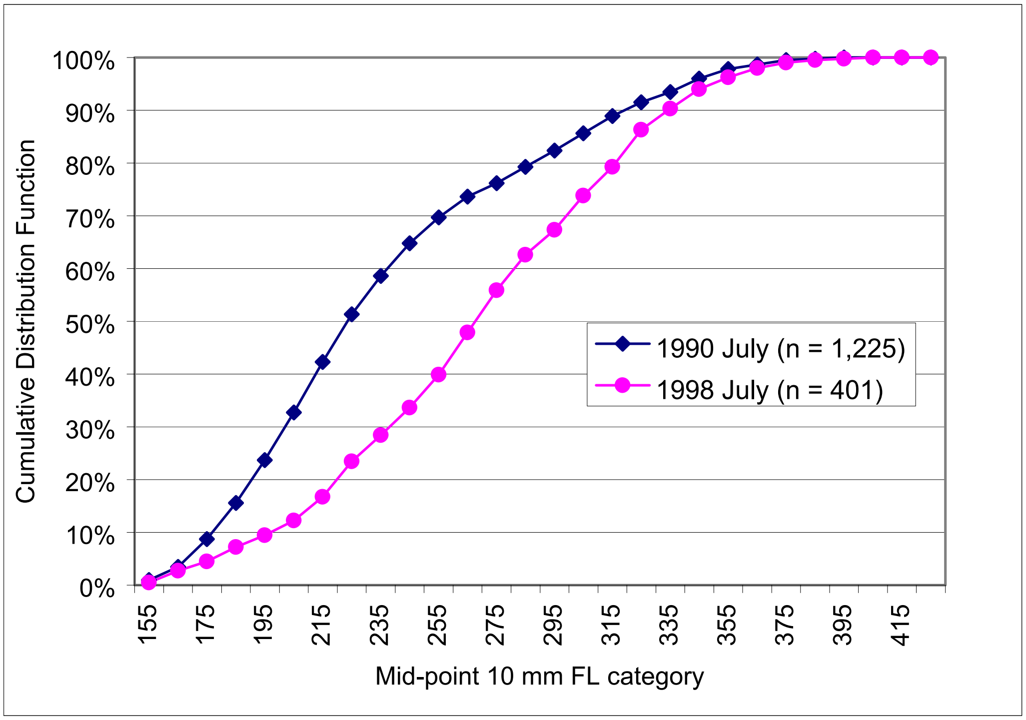


Figure 4.-Cumulative length distribution of Arctic grayling ≥150 mm FL sampled in the Gulkana River during 1990 and 1998 (Two-sample K/S Tests, DN = 0.32, P < 0.01).

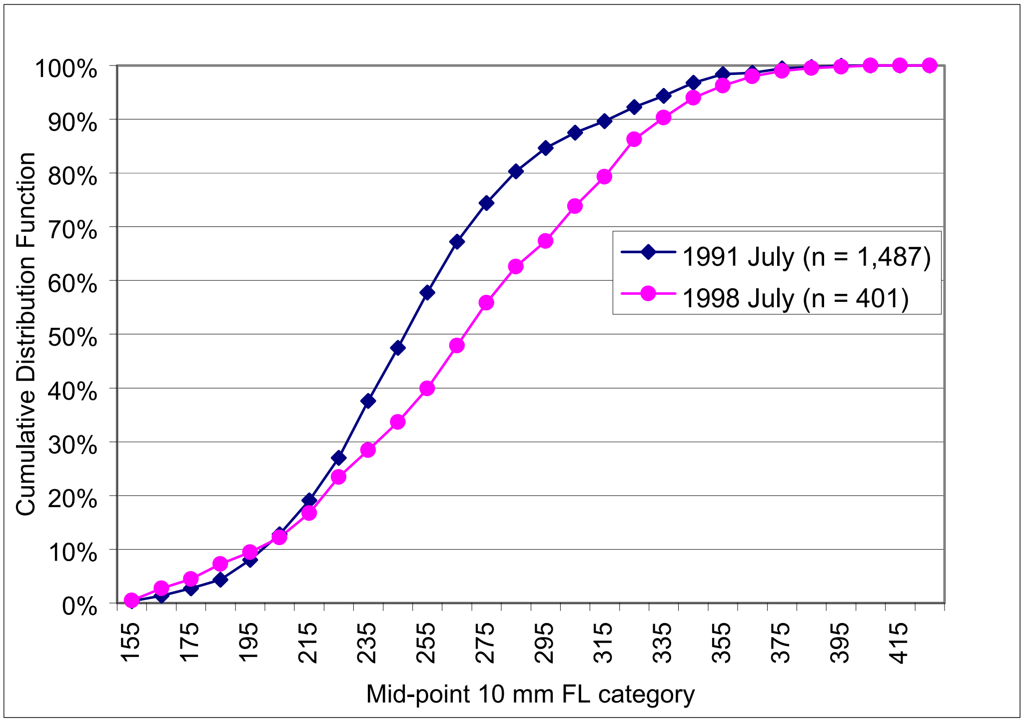


Figure 5.-Cumulative length distribution of Arctic grayling ≥150 mm FL sampled in the Gulkana River during 1991 and 1998 (Two-sample K/S Tests, DN = 0.21, P < 0.01).

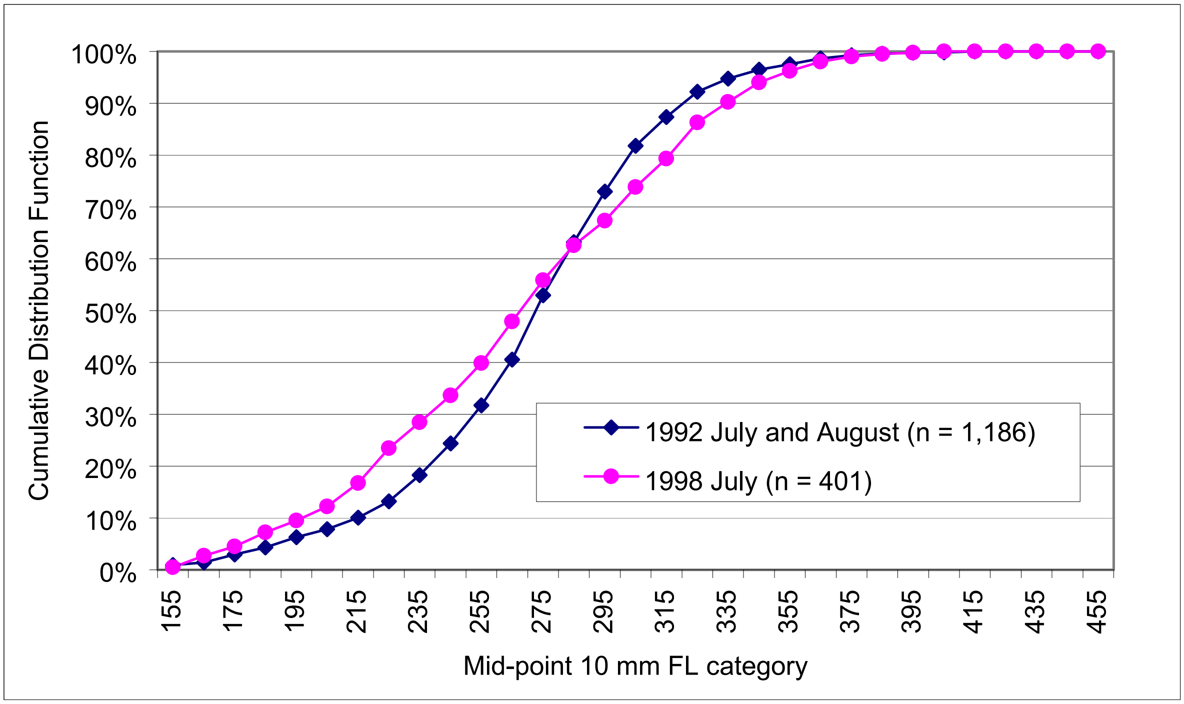


Figure 6.-Cumulative length distribution of Arctic grayling ≥150 mm FL sampled in the Gulkana River during 1992 and 1998 (Two-sample K/S Tests, DN = 0.11, P < 0.01).

Table 2.-Contingency table analysis of the frequency of Gulkana River Arctic grayling ≥320 mm FL (~14 inches and greater) captured during 1990, 1991, 1992, and 1998.

Year	< 320 mm FL	≥ 320 mm FL	Chi-square statistic
1990	1,098	127	$\chi^2 = 18.54$, $P < 0.01$, df = 1
1998	326	75	
1991	1,339	148	$\chi^2 = 22.38$, $P < 0.01$, df = 1
1998	326	75	
1992	1,056	130	$\chi^2 = 15.29$, $P < 0.01$, df = 1
1998	326	75	

Table 3.-Contingency table analysis of the frequency of Gulkana River Arctic grayling ≥ 270 mm FL (~12 inches and greater) captured during 1990, 1991, 1992, and 1998.

Year	< 269 mm FL	≥ 270 mm FL	Chi-square statistic
1990	908	317	$\chi^2 = 80.7$, $P < 0.01$, df = 1
1998	200	201	
1991	1,024	463	$\chi^2 = 49.11$, $P < 0.01$, df = 1
1998	200	201	
1992	521	665	$\chi^2 = 4.04$, $P = 0.04$, df = 1
1998	200	201	

Table 4.-Contingency table analysis of age composition of Gulkana River Arctic grayling ≥150 mm FL during 1990, 1991, 1992, and 1998.

Year	Total sample	Age 1	Age 2	Age 3	Age 4	Age 5	Age 6	Age 7	Age 7+	Chi-square Statistic
1990	459	88	206	69	36	27	24	7	2	$\chi^2 = 116.8$,
1998	364	39	61	118	60	39	24	12	11	$P < 0.01$, df = 7
1991	467	11	91	169	122	39	21	11	3	$\chi^2 = 44.5$,
1998	364	39	61	118	60	39	24	12	11	$P < 0.01$, df = 7
1992	638	1	20	119	216	185	67	18	12	$\chi^2 = 201.9$,
1998	364	39	61	118	60	39	24	12	11	$P < 0.01$, df = 7

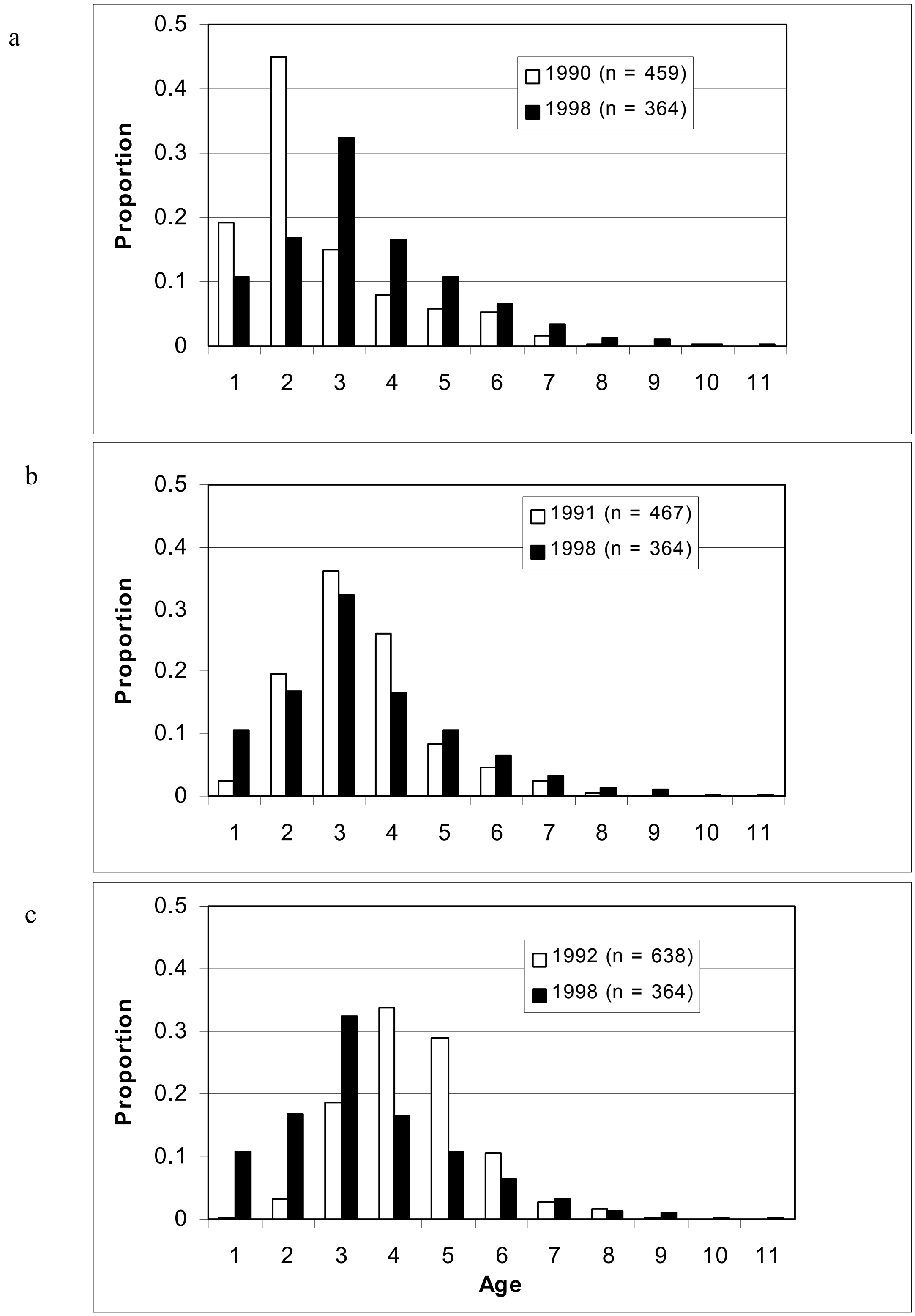


Figure 7.-Age composition of Arctic grayling sampled in the Gulkana River during 1998 and 1990(a), 1991(b), and 1992(c).

There are inherent problems in using stock composition without abundance information in the management of fisheries. Not the least of which is the possibility that, for a declining stock, composition proportions may not change drastically or at all. This would be the case when the decline is equal or similar across all age or length categories. Also, pulses of weak or strong recruitment tend to either over or under emphasize the presence of large fish. For example, when there is weak recruitment, composition data alone may indicate a greater presence of large fish than is actually present. The risk involved is especially high in cases where stock abundance is low and fishing pressure is high. In certain situations, however, like Gulkana River Arctic grayling where there is a historical series of composition and abundance data on a lightly exploited large stock of fish, composition data may be sufficient to trigger mark-recapture experiments, which more accurately describe the health of the stock and provide more solid information for management actions.

With a series of composition and abundance data from what is known as a healthy stock, minimum threshold levels can be determined and used to make inferences about the health of the stock. If the proportion of fish within any one category falls below the minimum, further investigation would then be warranted. Since the stock of Arctic grayling in the Gulkana River is considered healthy, a three to five year rotation in gathering composition data may be sufficient. It is believed that up to 12,000 fish may be harvested annually from the Gulkana River. Because harvest is currently much lower than 12,000 fish per year (on average less than 2,000 fish are currently harvested annually) and critical length categories are not below threshold levels, abundance information is not needed at this time.

ACKNOWLEDGEMENTS

This project and report were made possible by partial funding provided by the U.S. Fish and Wildlife Service through the Federal Aid in Sport Fish Restoration Act (16 U.S.C. 777-777K) under project F-10-14, Job Number R-3-2 (f).

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Appendix A

Data File Listing

Appendix A1.-Data files regarding Arctic grayling captured in the Gulkana River during 1990, 1991, 1992 and 1998, and archived by the Research and Technical Services of the Alaska Department of Fish and Game-Sport Fish Division.

Year	Files	Contents
1990	I001OLK0	July tagged fish
1990	I001OLL0	July recaptures
1990	I001OLM0	July <200 mm fish
1991	I001ORD1	July tagged fish
1991	I001ORE1	July recaptures
1991	I001ORF1	July <200 mm fish
1992	I001ORB2	July and August sampling
1998	I-000100L011998	July sampling

Appendix B

Data Summaries

Appendix B1.-Mean length-at-age of Arctic grayling ≥150 mm FL sampled in the Gulkana River during July 1998.

Age	n	Mean Length (mm FL)	SE
1	38	170	21
2	60	217	18
3	117	261	28
4	61	286	26
5	39	313	19
6	24	327	18
7	12	329	30
8	5	344	28
9	4	362	23
10	1	361	----
11	1	397	----

Appendix B2.-Composition by size class of Arctic grayling ≥150 mm FL sampled in the Gulkana River during July 1998.

Size Class	n	p	SE[p]	CV[p]
155	2	0.005	0.004	0.71
165	9	0.02	0.01	0.33
175	7	0.02	0.01	0.38
185	11	0.03	0.01	0.30
195	9	0.02	0.01	0.33
205	11	0.03	0.01	0.30
215	18	0.04	0.01	0.23
225	27	0.07	0.01	0.19
235	20	0.05	0.01	0.22
245	21	0.05	0.01	0.21
255	25	0.06	0.01	0.19
265	32	0.08	0.01	0.17
275	32	0.08	0.01	0.17
285	27	0.07	0.01	0.19
295	19	0.05	0.01	0.22
305	26	0.06	0.01	0.19
315	22	0.05	0.01	0.21
325	28	0.07	0.01	0.18
335	16	0.04	0.01	0.25
345	15	0.04	0.01	0.25
355	9	0.02	0.01	0.33
365	7	0.02	0.01	0.38
375	4	0.01	0.005	0.50
385	2	0.005	0.004	0.71
395	1	0.002	0.002	1.00
405	1	0.002	0.002	1.00
Totals	401	1.0		

Appendix B3.-Age composition of Arctic grayling ≥150 mm FL sampled in the Gulkana River during July 1998.

Age	n	p	SE[p]	CV[p]
1	39	0.11	0.02	0.15
2	61	0.17	0.02	0.12
3	118	0.32	0.02	0.08
4	60	0.16	0.02	0.12
5	39	0.11	0.02	0.15
6	24	0.07	0.01	0.20
7	12	0.03	0.01	0.28
8	5	0.01	0.01	0.44
9	4	0.01	0.01	0.50
10	1	0.003	0.003	1.00
11	1	0.003	0.003	1.00
Totals	364	1.0		